In-lake phytoplankton fluorescence data: assumptions, limitations, and tips for single-lake monitoring

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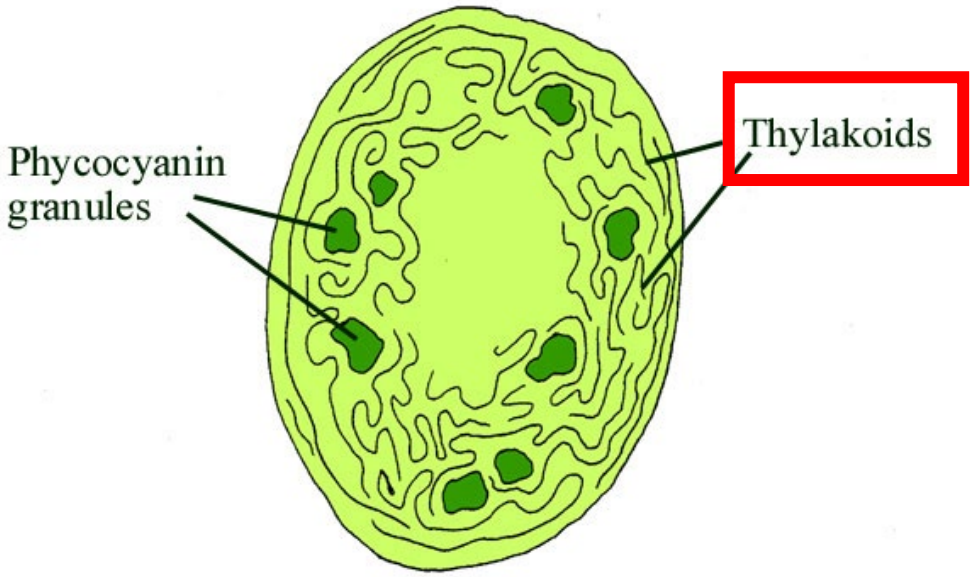
2: Water quality volunteer: Goodyear Lake, Culver Lake, Otsego Lake

Intro

- Why phycocyanin (PC), chlorophyll (Chl), PC:Chl ratio? – easy to measure, timely, can be informative
- Basic biology of photosynthesis & photopigments
- Utility and limitations
  - Nonphotochemical quenching and other interference
  - Relative fluorescence unit (RFU) to micrograms/L conversion issue
- Review of cell count - biomass - fluorescence relationship and sources of discrepancies

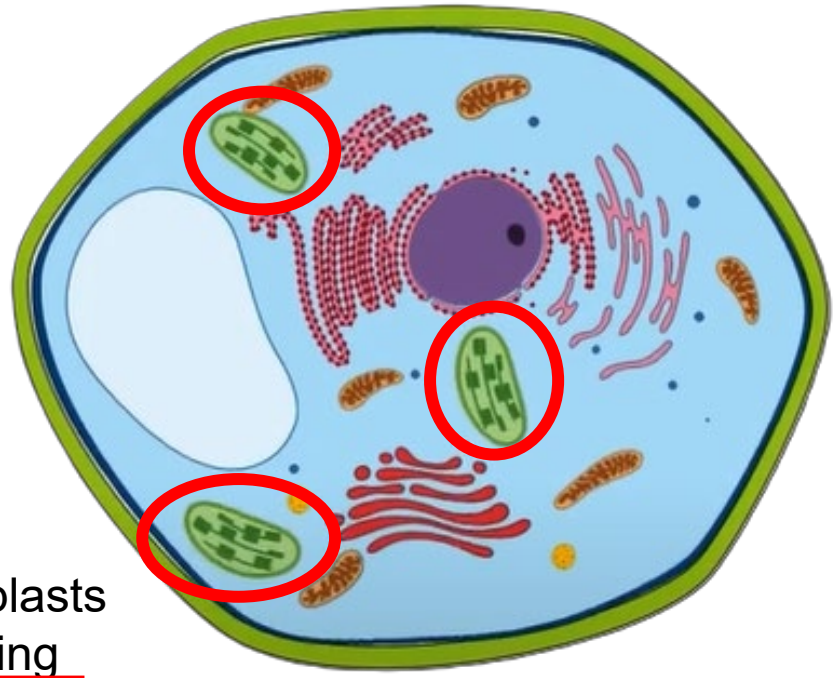
Cyanobacterium (prokaryote)



http://www.abdn.ac.uk/rhynie/images/plants/cyano/cyano4.jpg

Metabolic machineries floating around

Plant/algal cell (eukaryote)



Chloroplasts containing thylakoids

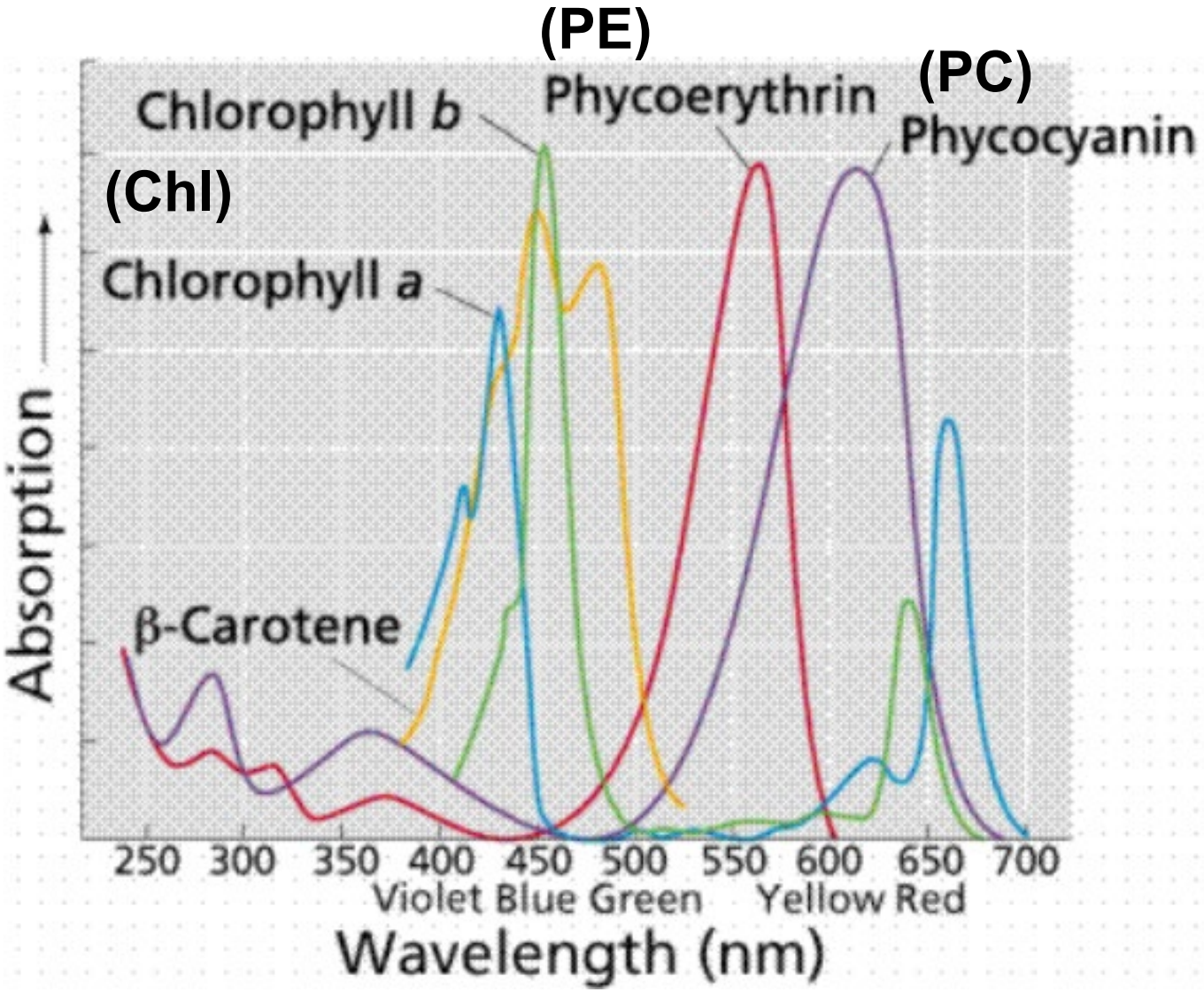
https://www.britannica.com/science/chloroplast

Metabolic machineries as membrane-bound organelles

Thylakoid membranes = site of photosynthesis

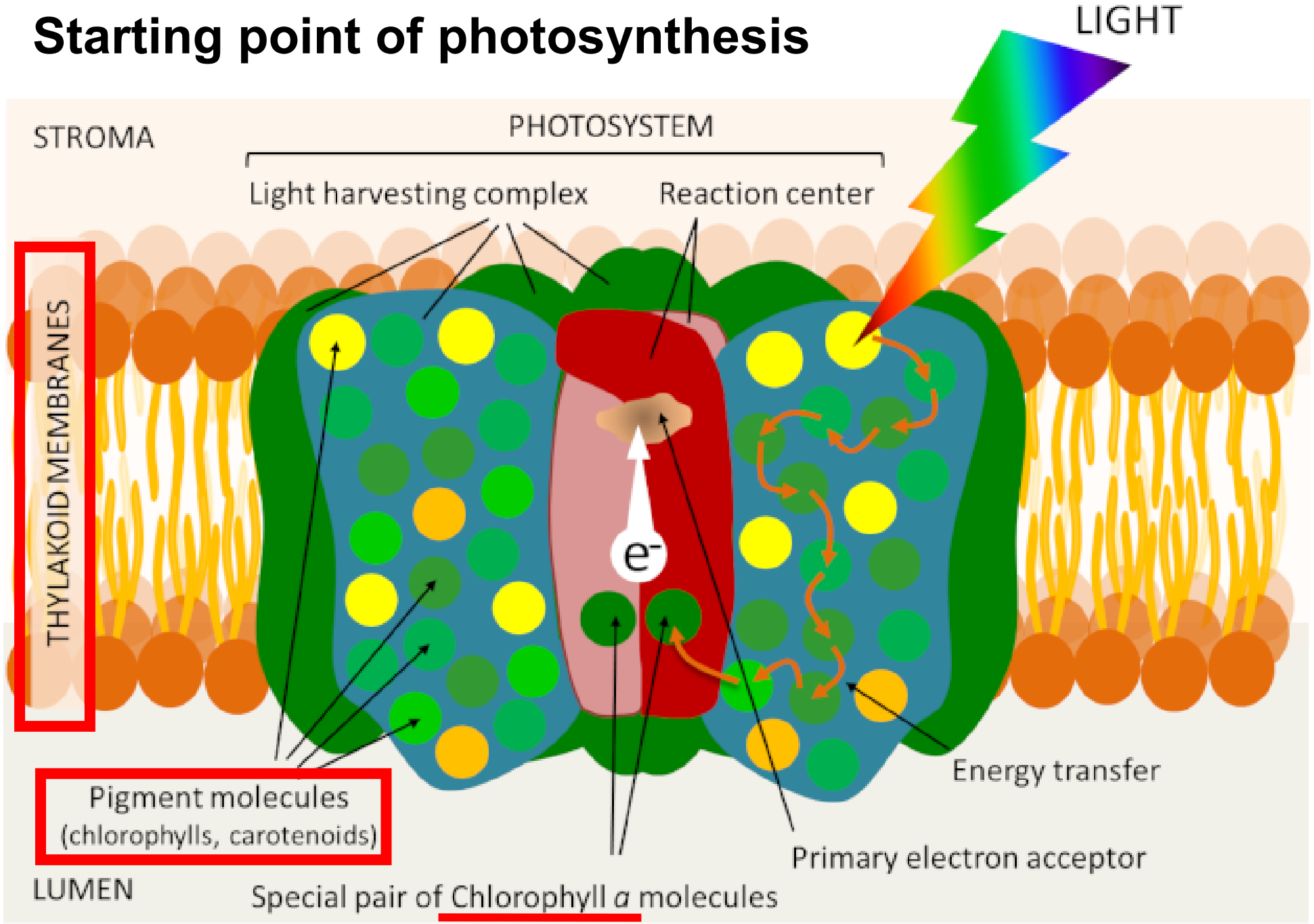
Photosynthesis by **phytoplankton**
(microalgae & cyanobacteria suspended in water)

- Chlorophyll = main photosynthetic pigment
  - Chl. *a* = common to all plants, algae, and cyanobacteria
- Accessory pigments (PC, PE, etc.) absorb additional light energy that chlorophyll cannot
- Absorbed light energy drives photosynthesis.



http://www.cas.miamioh.edu/~meicenrd/bmz116/biobps.html

Starting point of photosynthesis

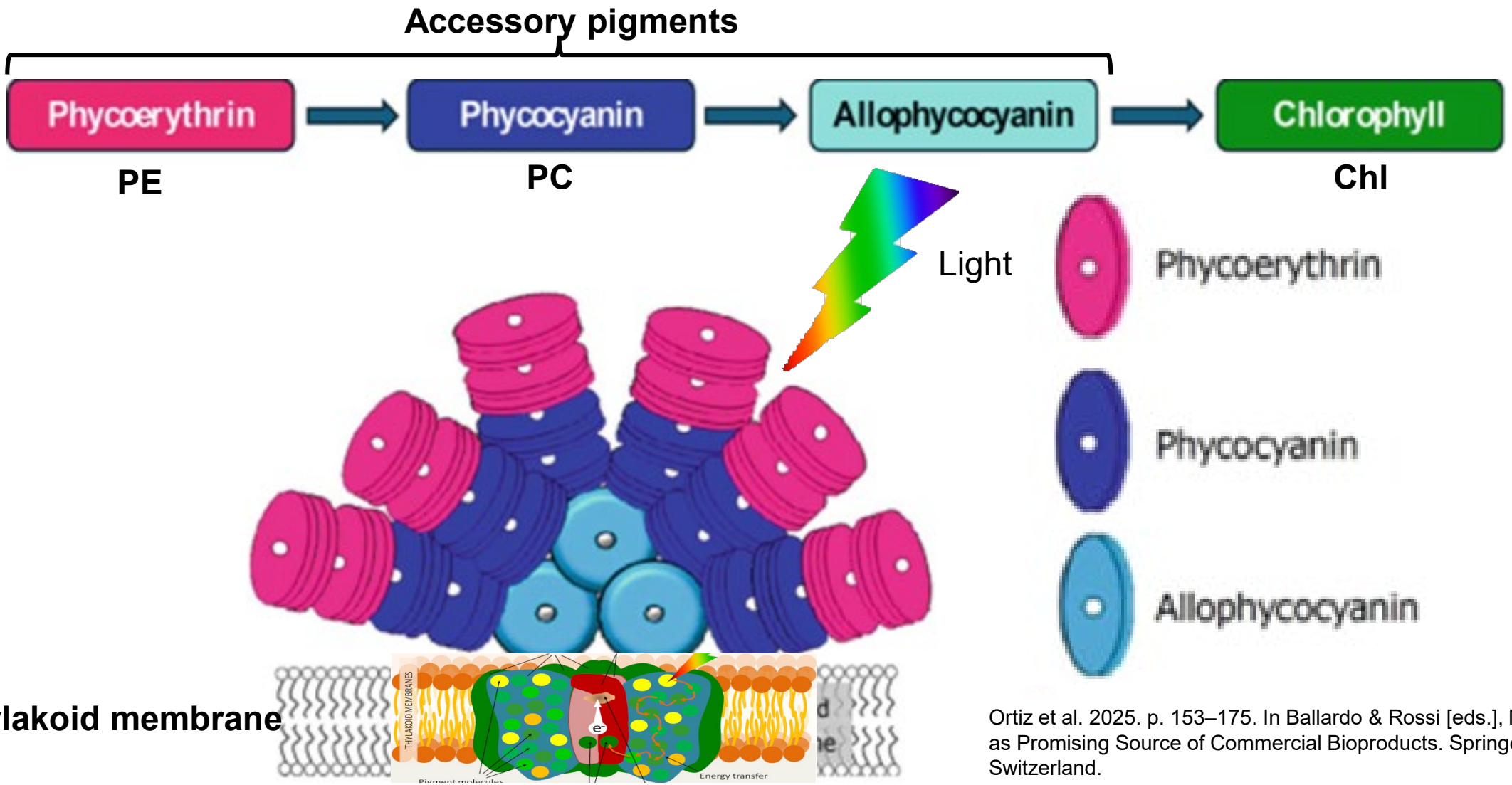


Excess light energy is emitted as heat (via nonphotochemical quenching) **and fluorescence** to reduce damage

Ambient light, temp, turbidity, and **colored dissolved organic matter** can interfere with fluorescence readings

https://www.encyclopedie-environnement.org/en/life/shedding-light-on-photosynthesis-2/

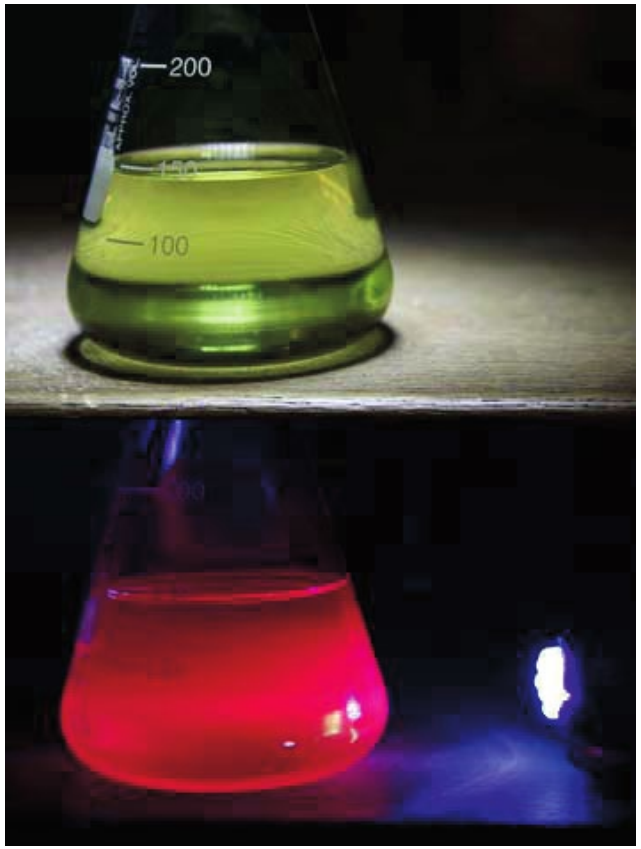
Cyanobacteria (and some algae) have a light-harvesting antenna (phycobilisome) above photosystem



Ortiz et al. 2025. p. 153–175. In Ballardo & Rossi [eds.], Microalgae as Promising Source of Commercial Bioproducts. Springer Nature Switzerland.

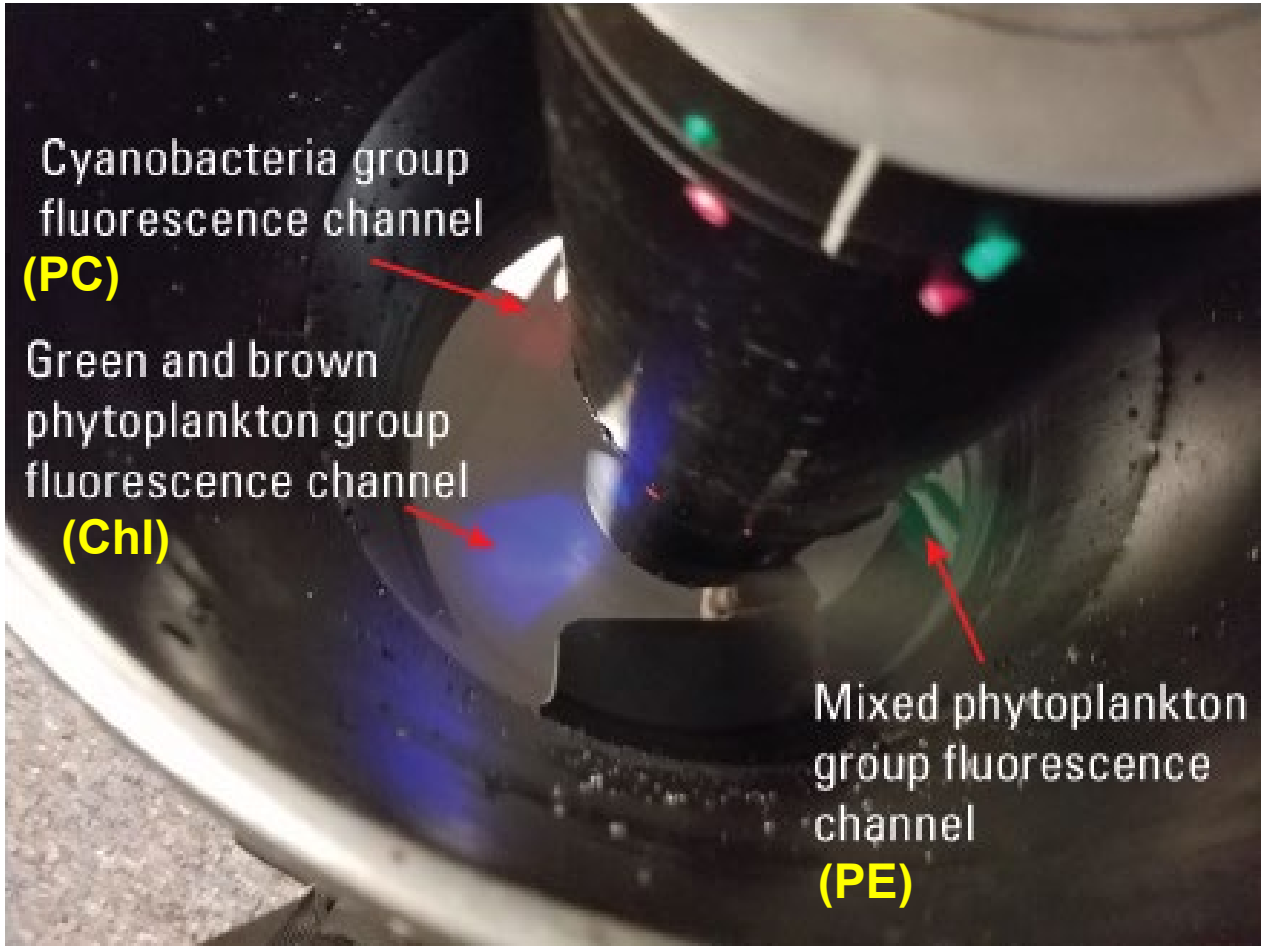
- Each photosynthetic pigment fluoresces differently in response to light
- Multi-channel fluorometry
  → relative fluorescence unit (RFU) values for each target pigment

Chlorophyll is excited by UV/blue light and fluoresces in red



Mitra (2019). Resonance. 24. 623. doi: 10.1007/s12045-019-0821-5

An example of a multi-channel fluorometric probe



Johnston et al. 2022. Scientific Investigations Report 2022-5103. USGS. https://doi.org/10.3133/sir20225103

We used **PC RFU:chl RFU ratio** as a simple index to monitor **which fluorescence was dominant** at a given time, site, and depth.

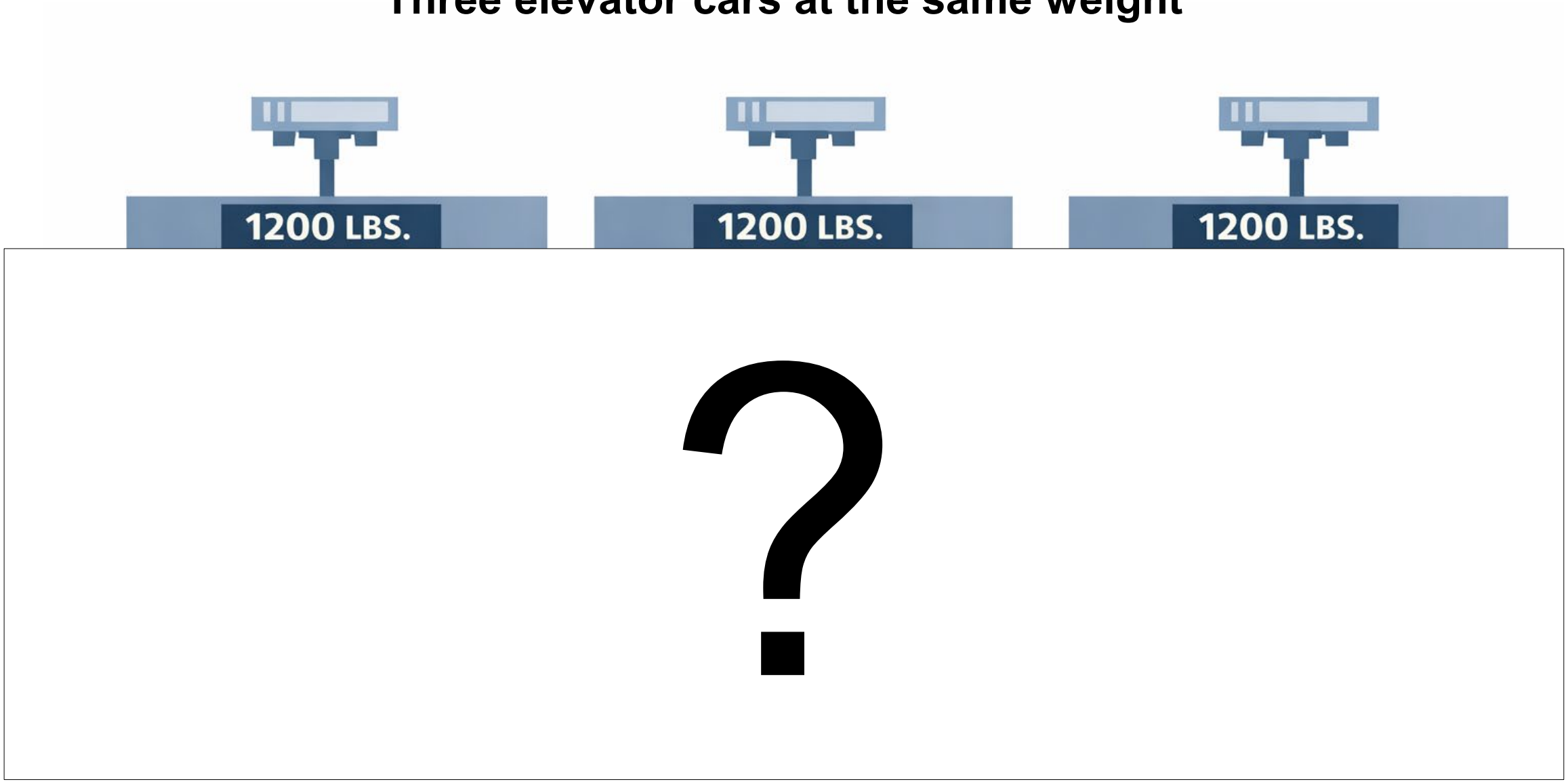
- Comparison with observed cHAB events at two lakes

- Reduced influence of ambient light, temp, cDOM, turbidity, etc.
  - Both RFUs measured simultaneously within a few inches

- Avoided using “microgram/L” values for pigments
  - Auto-calculated by equipment
    - Not reliable unless calibrated against extracted lab samples for each lake/system (e.g., Foster et al. 2022; Prestigiacomo et al. 2022)
    - RFU to microgram/L algorithms are proprietary and vary across manufacturers, models, and individual units

Note: RFU-derived “% chlorophyll”, biomass, or cell counts are also problematic

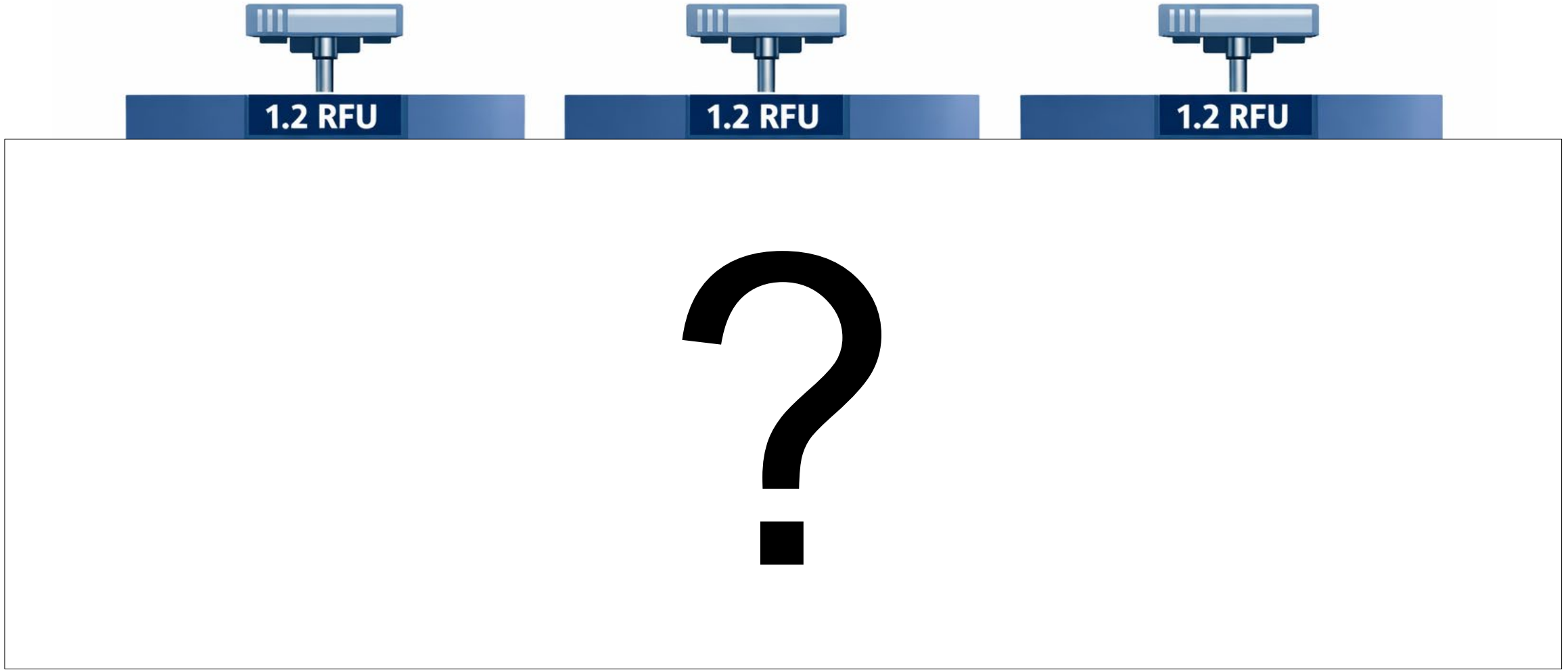
Three elevator cars at the same weight



The weight sensors cannot tell the sources of the weight – types, #s, etc.

Illustration generated by Copilot AI

Three fluorometers with the same Chl RFU



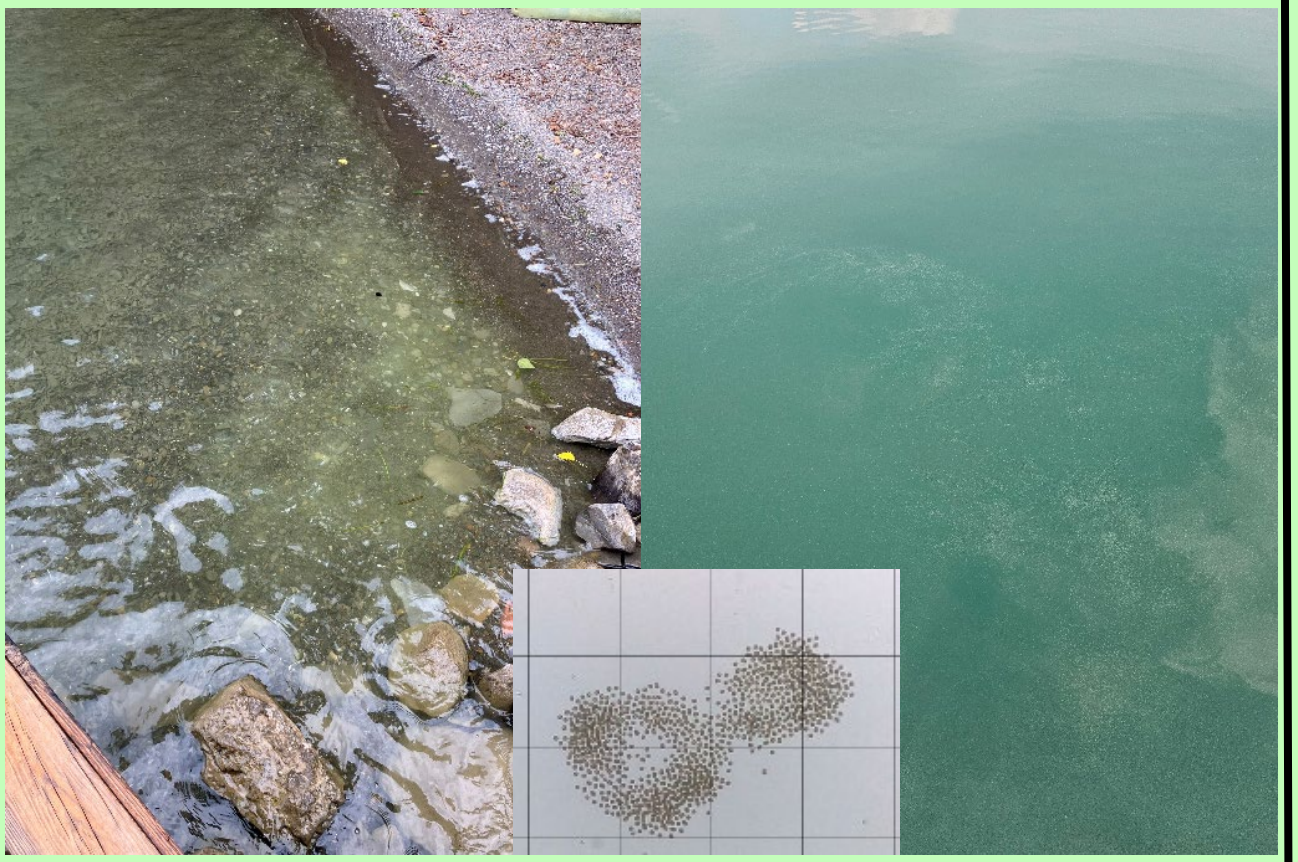
The sensors cannot tell the sources of Chl fluorescence nor environmental interference

Illustration generated by Copilot AI

Two case studies:
Contrasting waterbodies

Otsego Lake, NY - 4000 acres

Mostly localized blooms of *Microcystis*



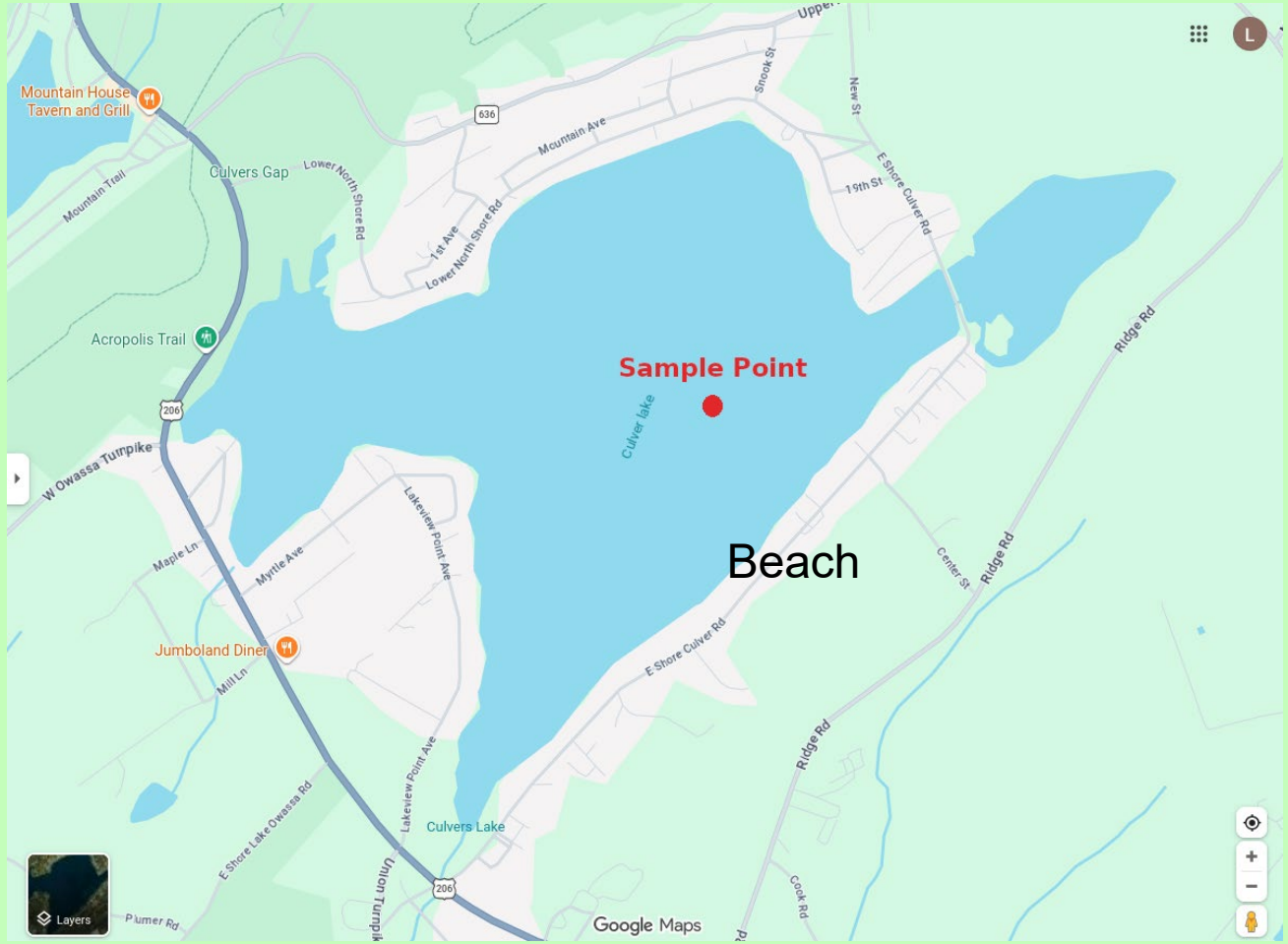
Source: NYHABS 2.0, 6 Aug 2025, photomicrograph grids = 100 microns x 100 microns

Culver Lake, NJ – 550 acres

Shoreline blooms of *Aphanizomenon*

Culver Lake, NJ Case Study

Surface Area	550 acres
Mean Depth	5 meters (16 feet)
Maximum Depth	15.5 meters (50 feet)
Summer Thermocline	5-6 meters (16 feet)
Classification	Meso-eutrophic
Human Impact	Small home lots, 450 members 50% on / off lakefront



Background

- Clubhouse, beach with guards
- Focus on Memorial day to Labor Day
- Awareness / influence of NJ DEP HAB cell count classification
- Lake has experienced localized HABs over last 5 years
- Strong Water Quality culture
  - Water Quality committee, volunteers
  - Professional Lake Manager
  - 30 years of data collection
- YSI RFU technology investment 5 years ago (approximate)

NJ HAB recreational guidelines

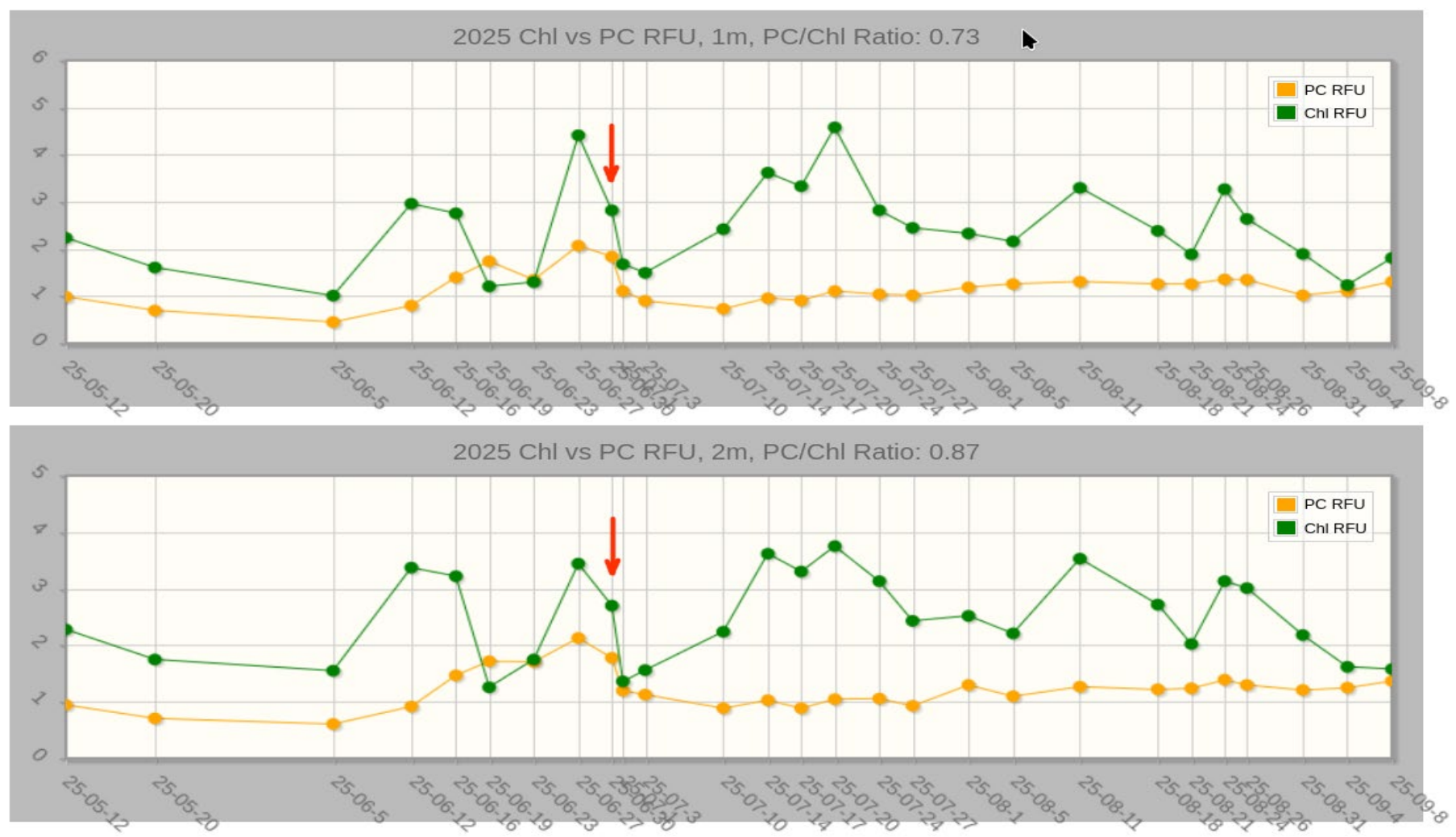
HAB ALERT LEVEL	CRITERIA	RECOMMENDATIONS
NONE	No HAB present or reported.	None
WATCH *Suspected or confirmed HAB with potential for allergenic and irritative health effects*	Suspected HAB based on visual assessment or screening test **OR** Lab confirmed cell counts between 20k – 40k cells/mL **AND** No known toxins above public health thresholds	Public Bathing Beaches Open (dependent upon local health authority evaluation and assessment) Waterbody Accessible: ➢ Use caution during primary contact (e.g. swimming) and secondary (e.g. non-contact boating) recreational activities Do not ingest water (people/pets/livestock) Do not consume fish
ALERT *Confirmed HAB that requires greater observation due to increasing potential for toxin production* PUBLIC BATHING BEACHES INCREASE MONITORING	Lab confirmed cell counts between 40k – 80k cells/mL **AND** No known toxins above public health threshold	WATCH remains in effect. Public Bathing Beaches Open (dependent upon local health authority evaluation and assessment) and should observe and report changing bloom conditions Waterbody Accessible: ➢ Use caution during primary contact (e.g. swimming) and secondary (e.g. non-contact boating) recreational activities Do not ingest water (people/pets/livestock) Do not consume fish
ADVISORY *Confirmed HAB with **moderate risk** of **adverse health effects** and increased potential for toxins above public health thresholds*	Lab testing for toxins exceeds public health thresholds **OR** Lab confirmed cell counts above 80K cells/mL **OR** Field measurement evidence indicating HAB present and above guidance thresholds (e.g. phycocyanin readings)	Public Bathing Beaches Closed Waterbody Remains Accessible: ➢ Avoid primary contact recreation (e.g. swimming) ➢ Use caution for secondary contact recreation (e.g. boating without water contact) Do not ingest water (people/pets/livestock) Do not consume fish
WARNING *Confirmed HAB with **high risk** of **adverse health effects** due to high toxin levels*	Toxin (microcystin) 20 - 2000 µg/l **AND/OR** Additional evidence, including, expanding bloom, increasing toxin levels (i.e. duration, spatial extent or negative human or animal health impacts) indicates that additional recommendations are warranted	Public Bathing Beaches Closed Waterbody Remains Accessible: ➢ Avoid primary contact recreation (e.g. swimming) ➢ May recommend against secondary contact recreation (e.g. boating without water contact) with additional evidence Do not ingest water (people/pets/livestock) Do not consume fish

Clubhouse

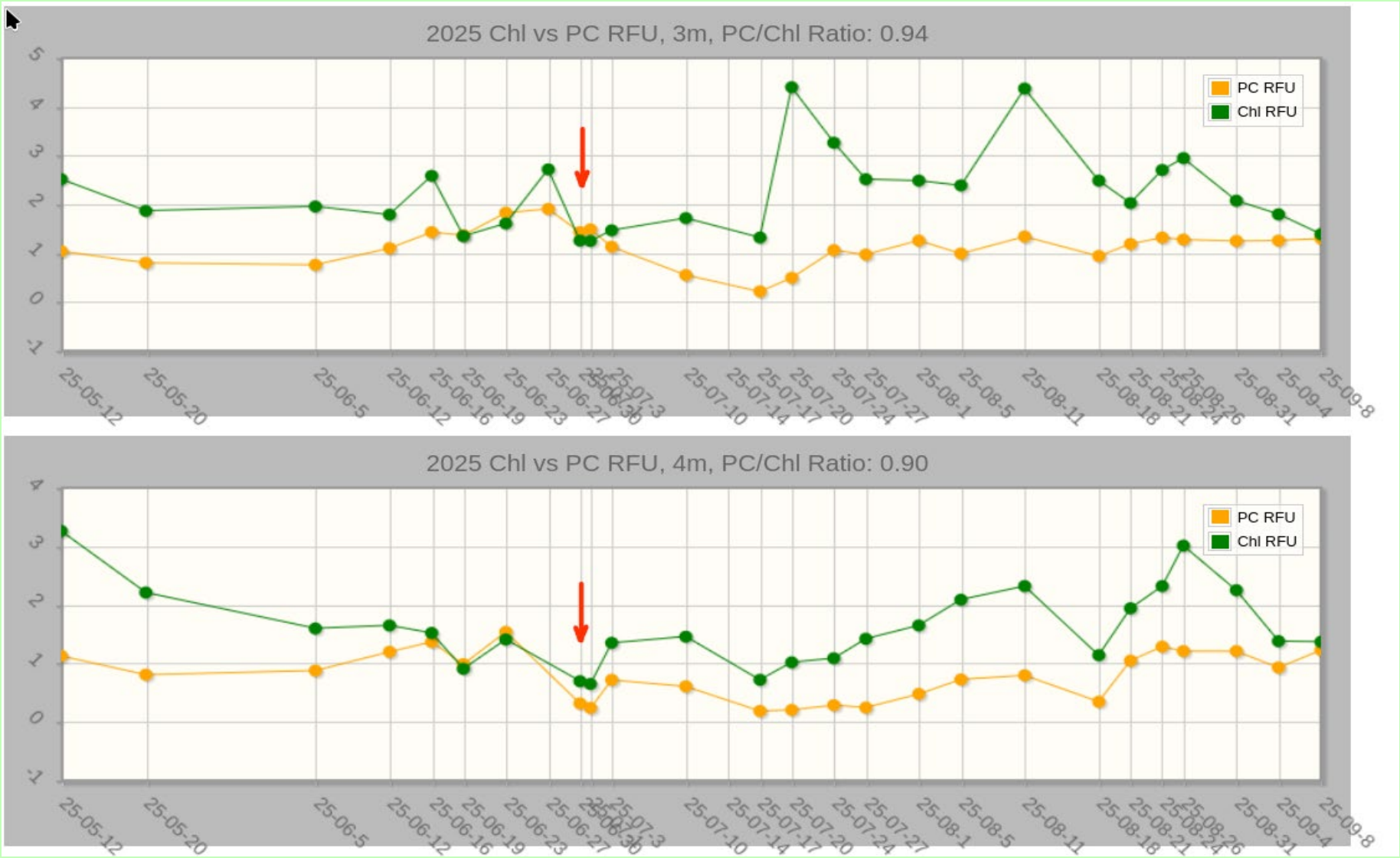
Technology

- YSI Pro DSS GPS, 16 parameters, PC download
- Weekly / biweekly reading
- Data consistently taken at single point in lake
- Readings at surface and 1 – 14 meters
- Late April through Early September
- RFU is currently considered at 1, 2, 3, 4 meters

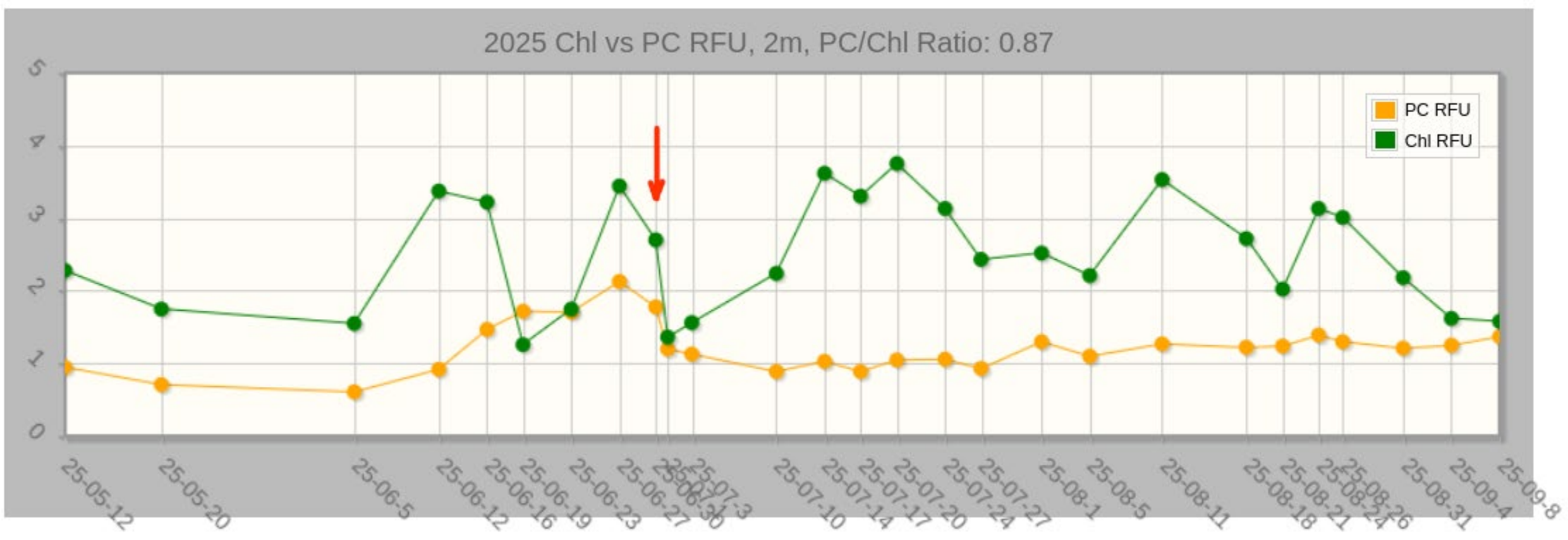
2025 RFU data 1,2 meters



2025 RFU data 3,4 meters



2 Meter – Discussion, Culver



- Mid-June (Red Arrow):
  - converging RFU ratio, supported by:
  - decreased secchi. increasing cell counts, prior year spring experience
- Decision taken for limited (50 acres) alegicide (chelated cooper) treatment
- Improved lake conditions (for duration of season), secchi clarity and RFU readings

Discussion, Conclusions, Culver

- Mid-June (Red Arrow):
  - converging RFU ratio, supported by:
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- Decision taken for limited (50 acres) alegicide (chelated copper) treatment
- Improved lake conditions (for duration of season), secchi clarity and RFU readings

- Actions resulted in increased RFU awareness for management
- Late season increased RFU convergence (lake turnover)
- Use of website for community awareness
  - https://lipnickey.com/norm-rfu/

- For this data set, RFU convergence serves as an indicator HAB formation
- Confirm with other sources, cell count if available, visual, secchi

Otsego Lake

County: Otsego

Surface Area: 4,046 Acres **Mean Depth: 82 ft**

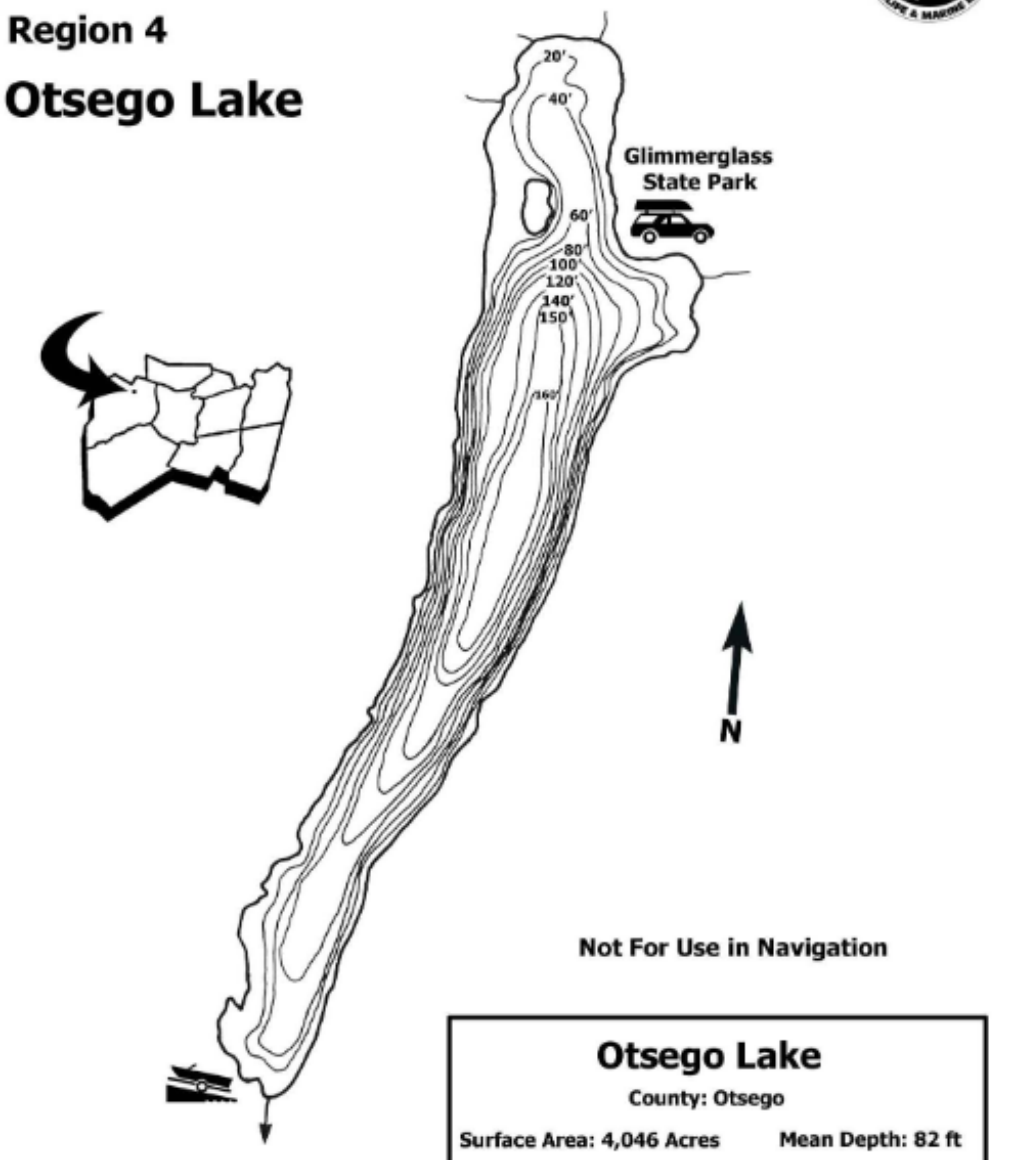
Fish Species Present: Bluegill, Brown Bullhead, Cisco, Atlantic Salmon, Largemouth Bass, Lake Trout, Chain Pickerel, Pumpkinseed, Rock Bass, Smallmouth Bass, Walleye, Lake Whitefish, Yellow Perch, Brown Trout

https://www.innatcooperstown.com/our-blog/how-to-see-the-kingfisher-tower-in-cooperstown/

New York State Department of Environmental Conservation
Division of Fish, Wildlife and Marine Resources
Lake Map Series

Region 4

Otsego Lake



Not For Use in Navigation

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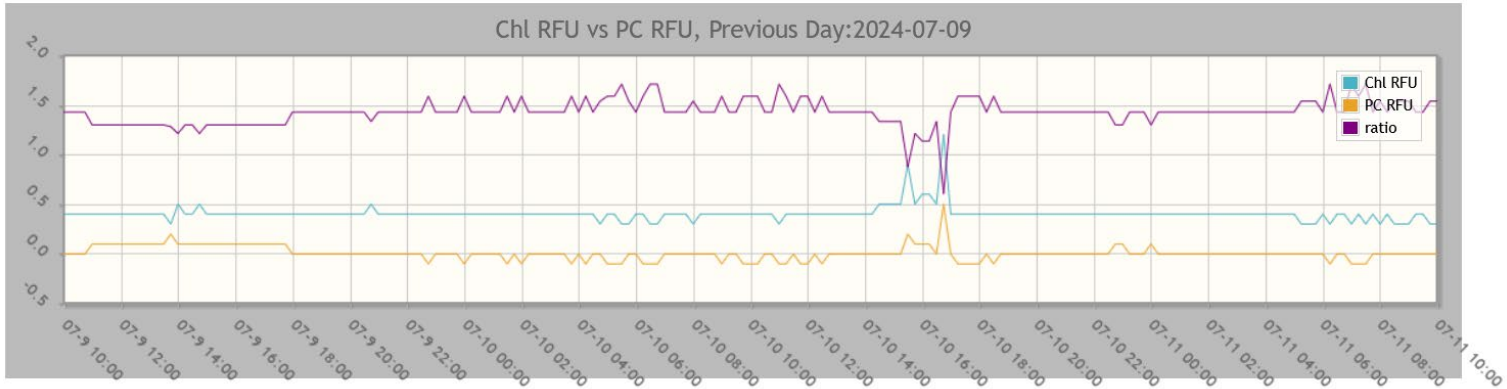
Scale: 0 4655 ft

Otsego Lake NY Case Study

- Nexsens CB-950 data buoy
- Sondes at z = 4 & 37 m
  (12 & 121 ft)
- Weather Station on top
- Data transmitted by wireless data service
- Cloud-based data storage
- Chl & PC sensors at 4 m (12 ft)
  - Surface blooms cannot be captured



In-season PC: Chl ratio display example

down to 48 m (145 ft) deep

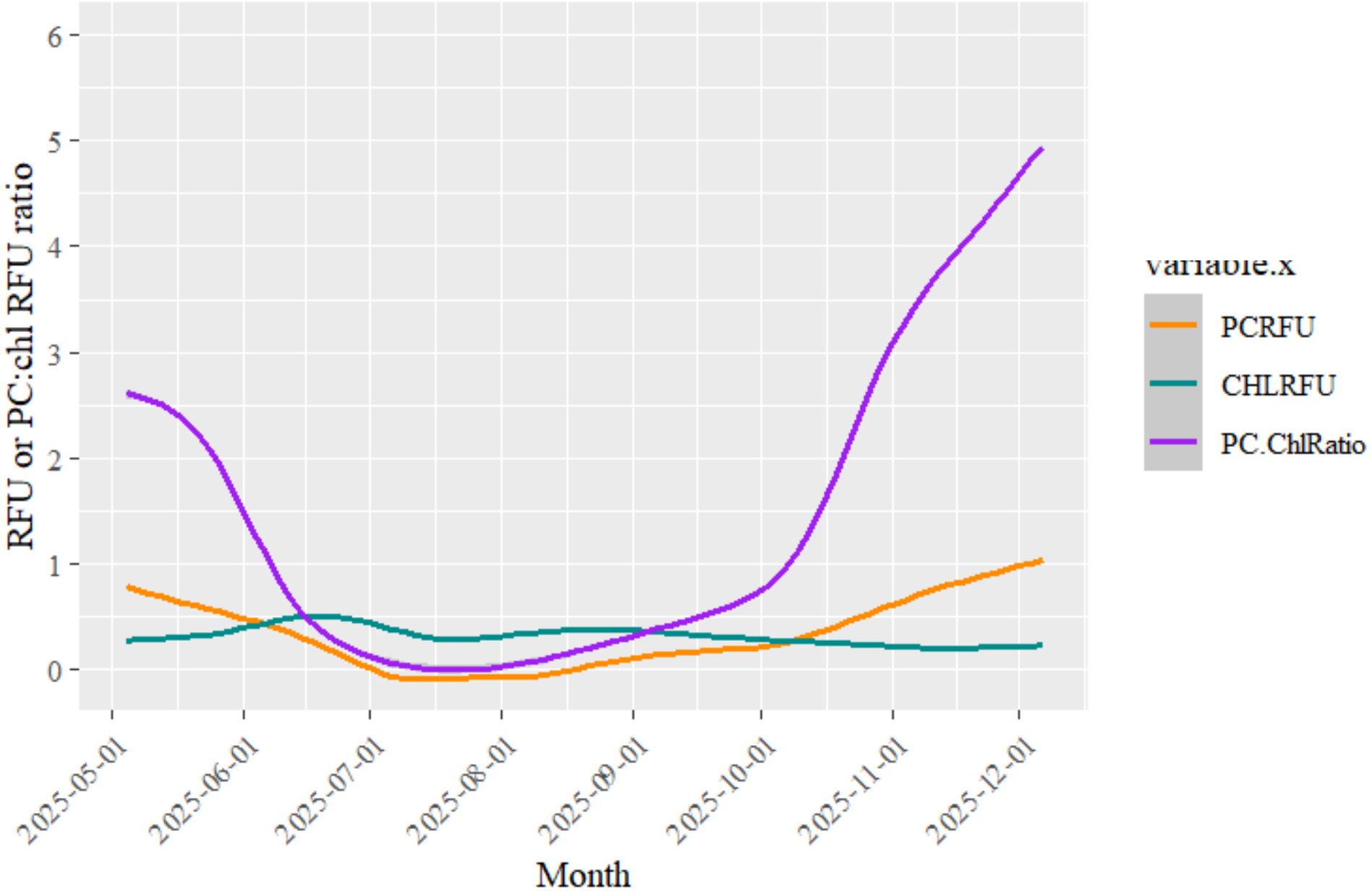
Modified from jpbuoy.com

EXO 2 sonde with multiple probes for different water quality parameters

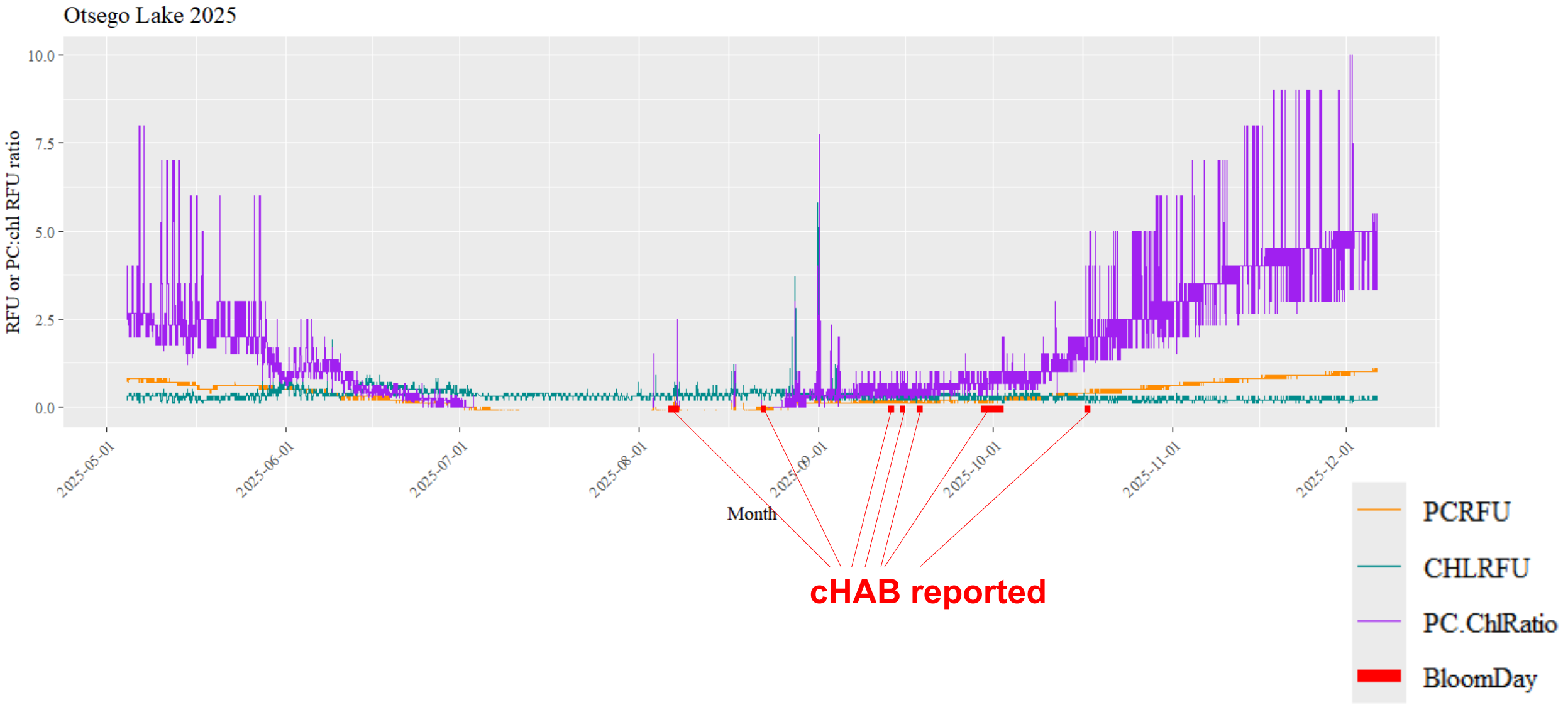
Nexsens CB-950 buoy frame

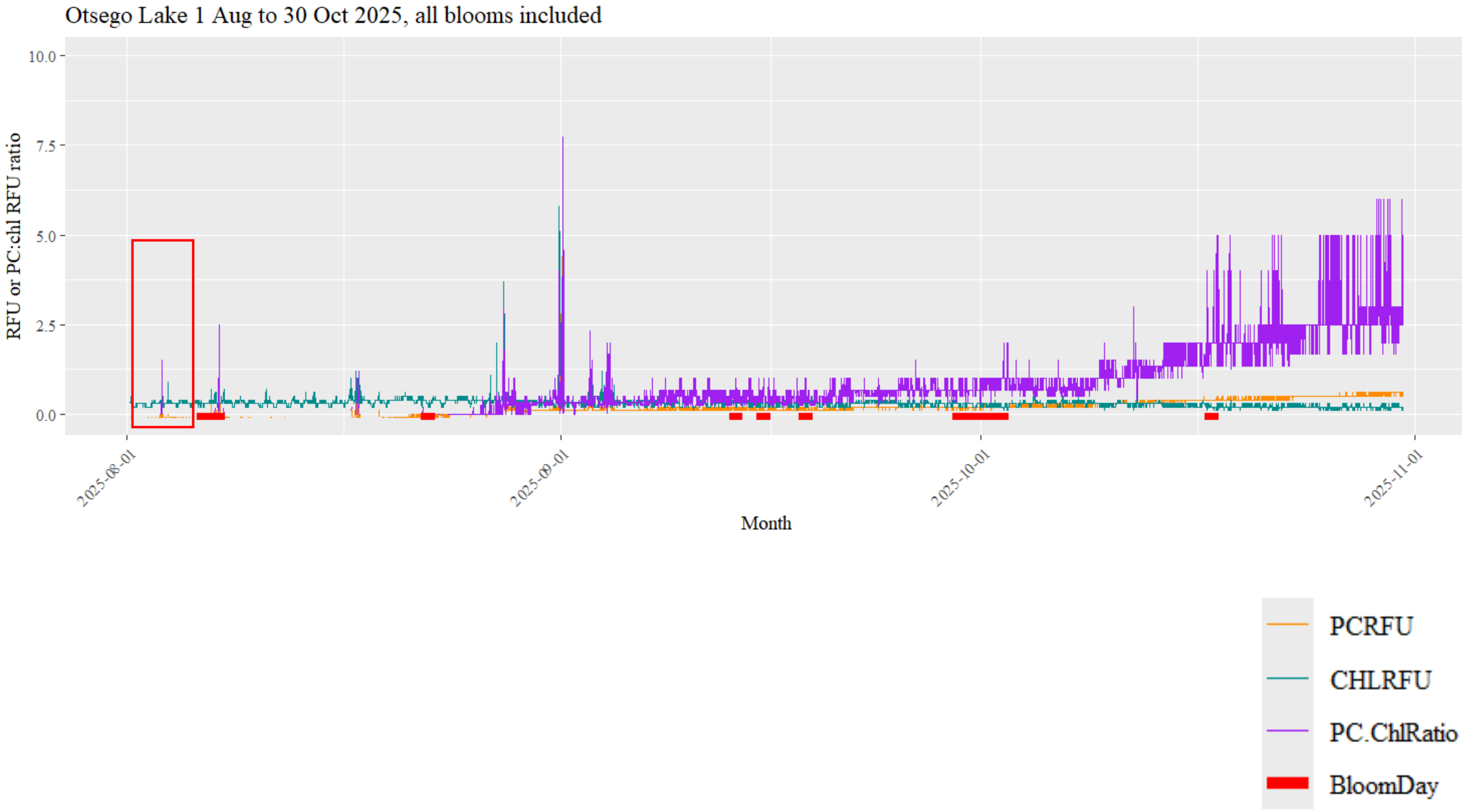
Smoothed 2025 data

PC:Chl ratio high in spring/fall, low in summer

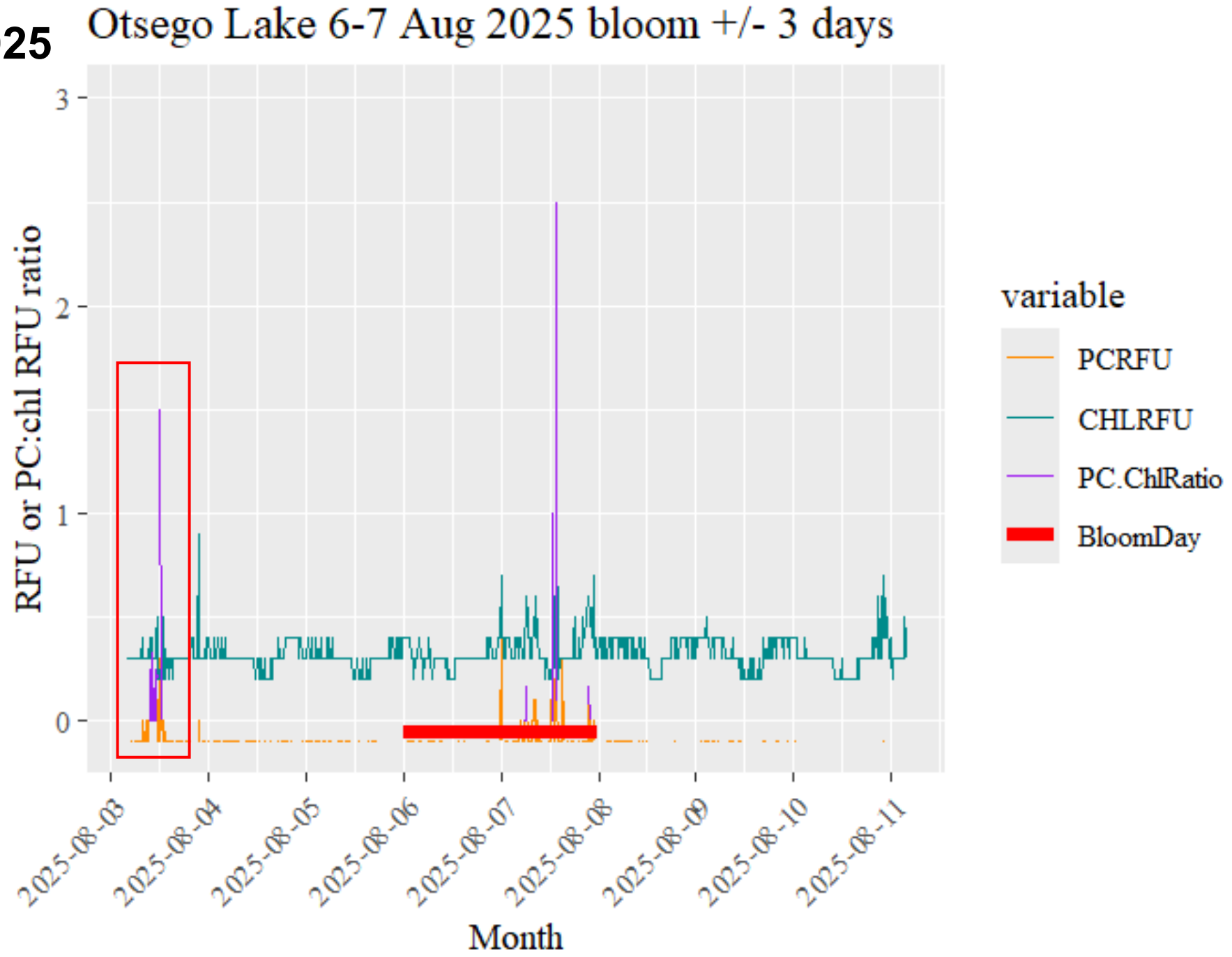


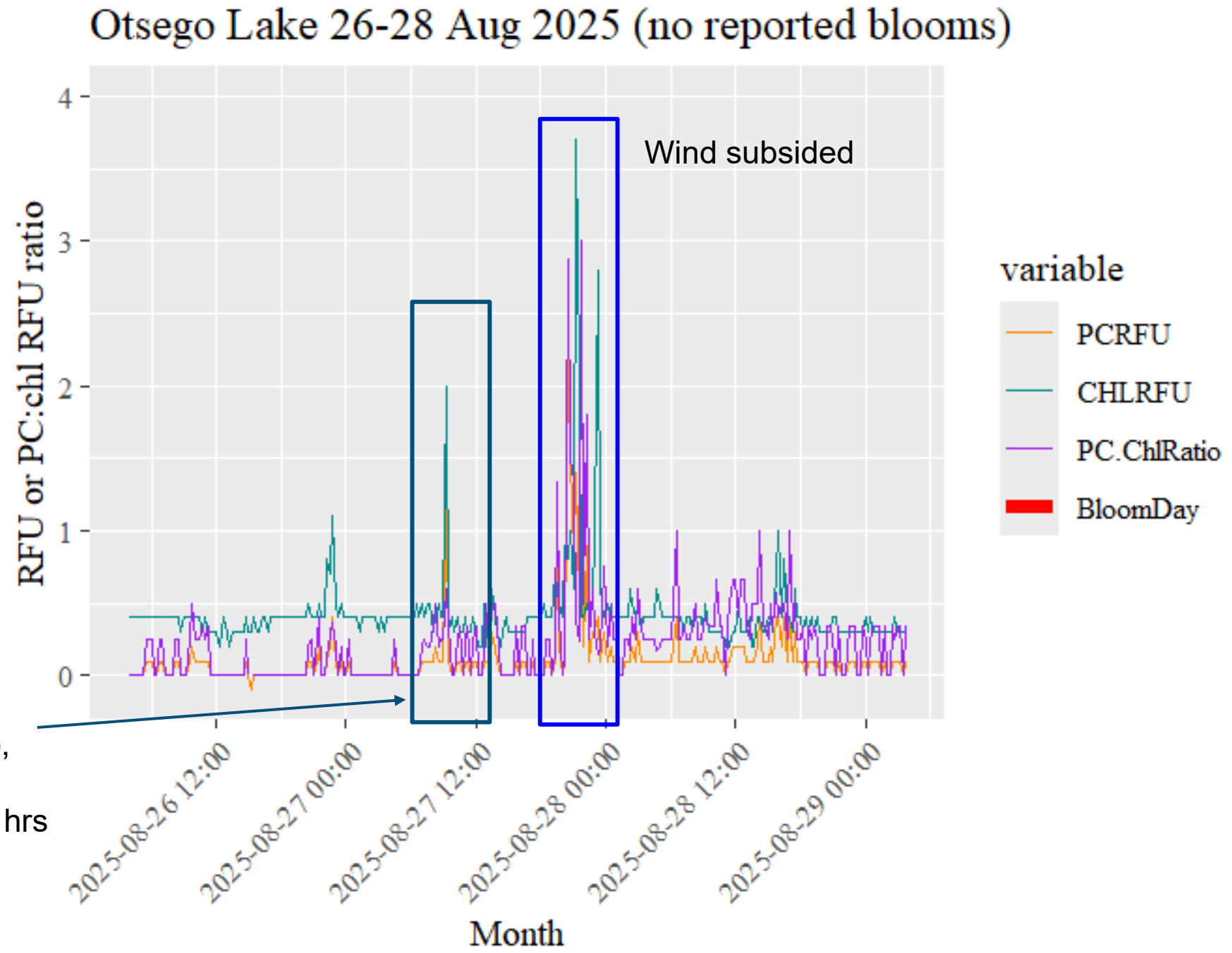
Unsmoothed 2025 data



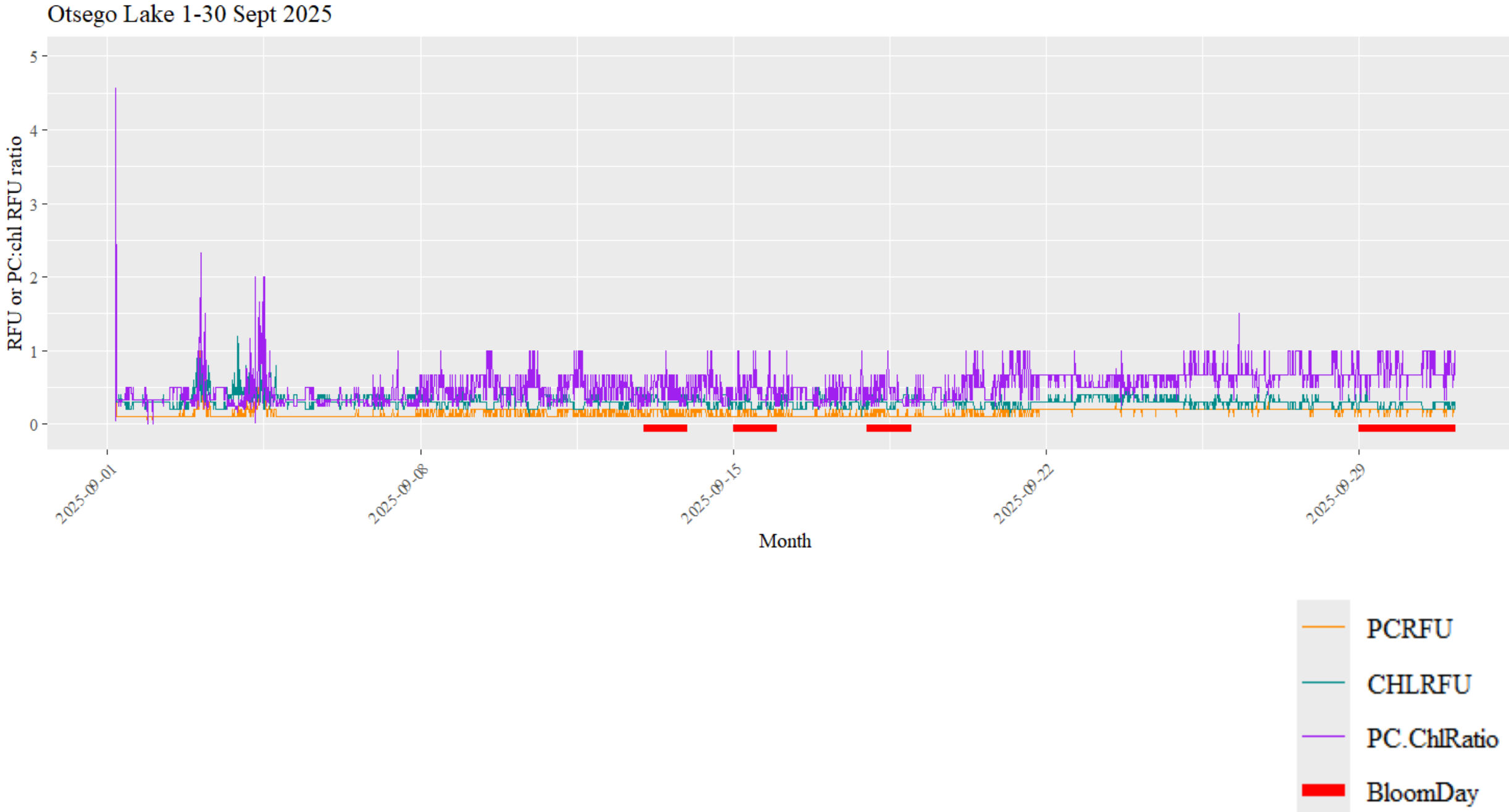

Otsego Lake 1 Aug to 30 Oct 2025, all blooms included
RFU or PC:chl RFU ratio
10.0
7.5
5.0
2.5
0.0
2025-08-01
2025-09-01
2025-10-01
2025-11-01
Month
PCRFU
CHLRFU
PC.ChlRatio
BloomDay

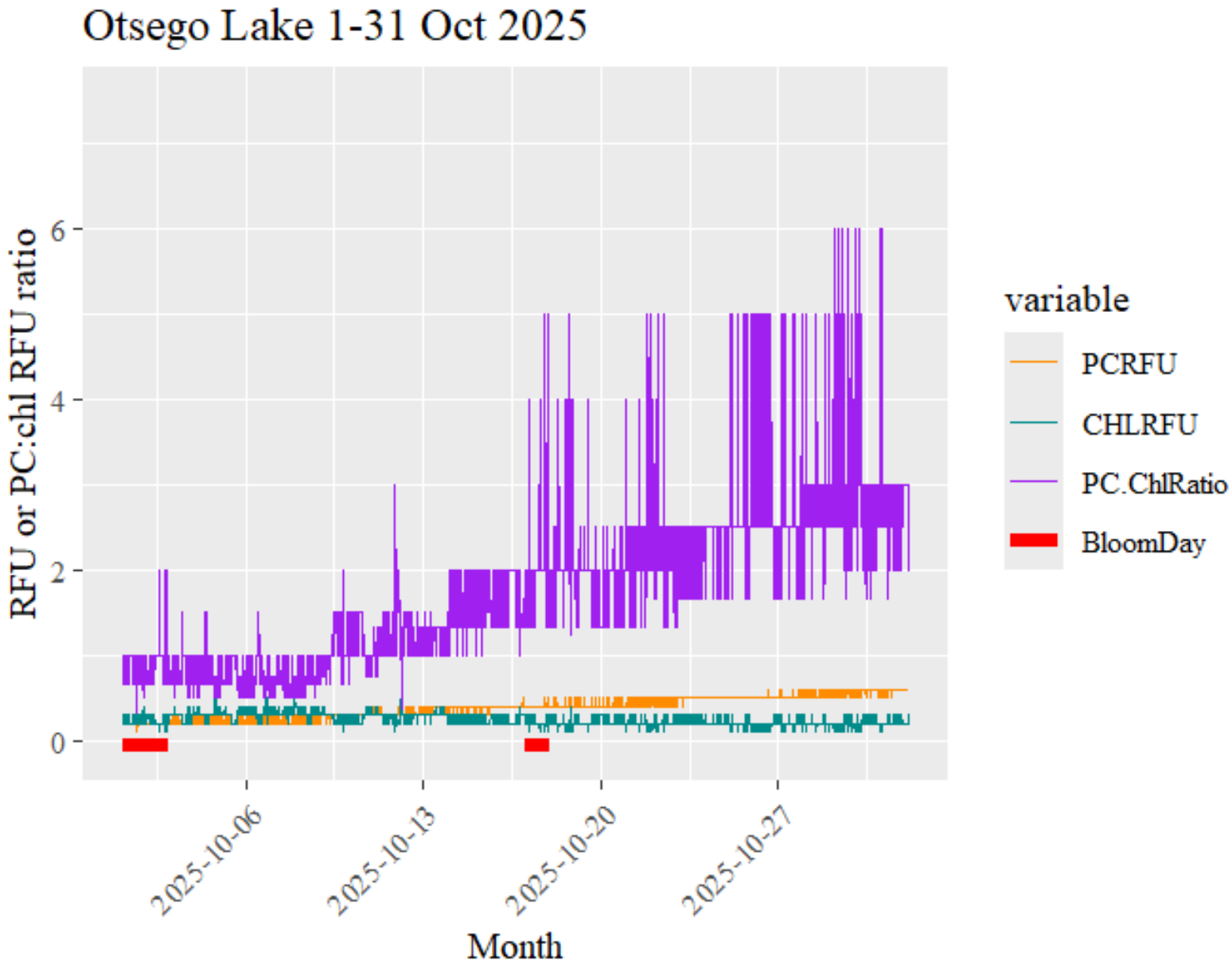
1st bloom in 2025



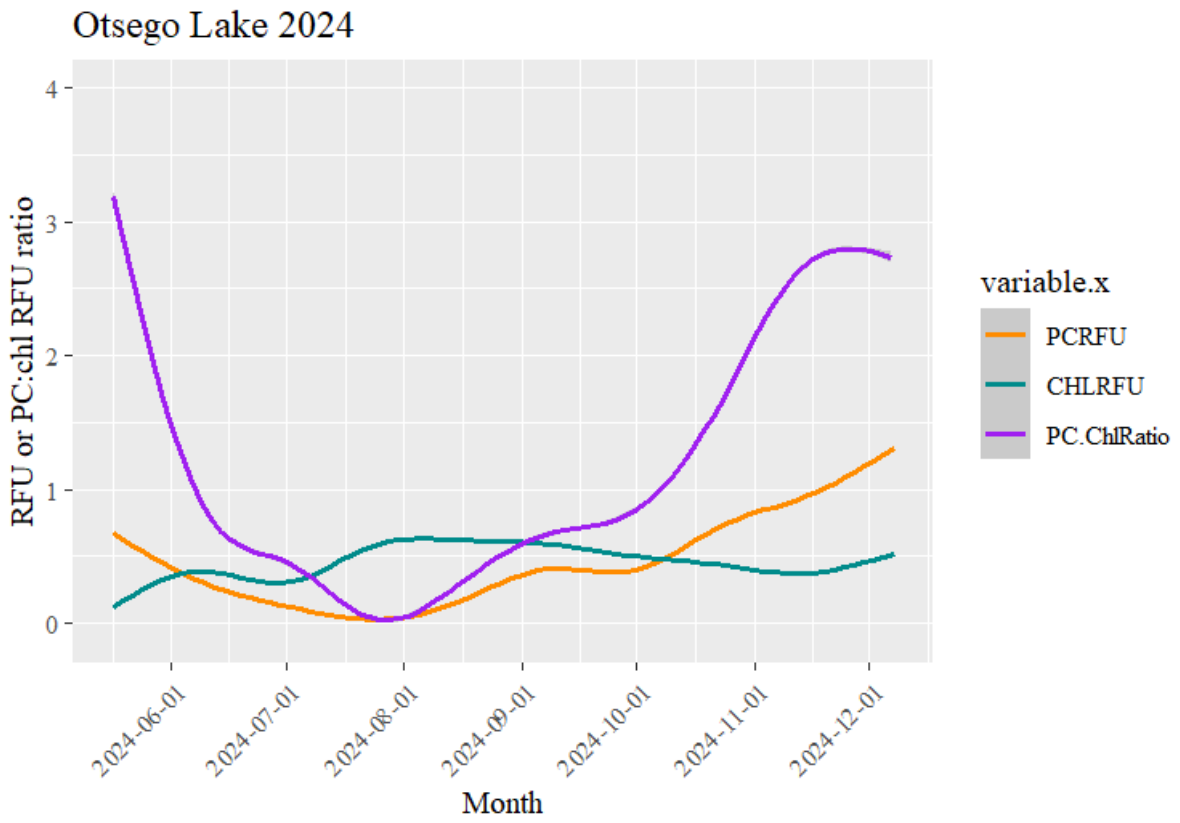


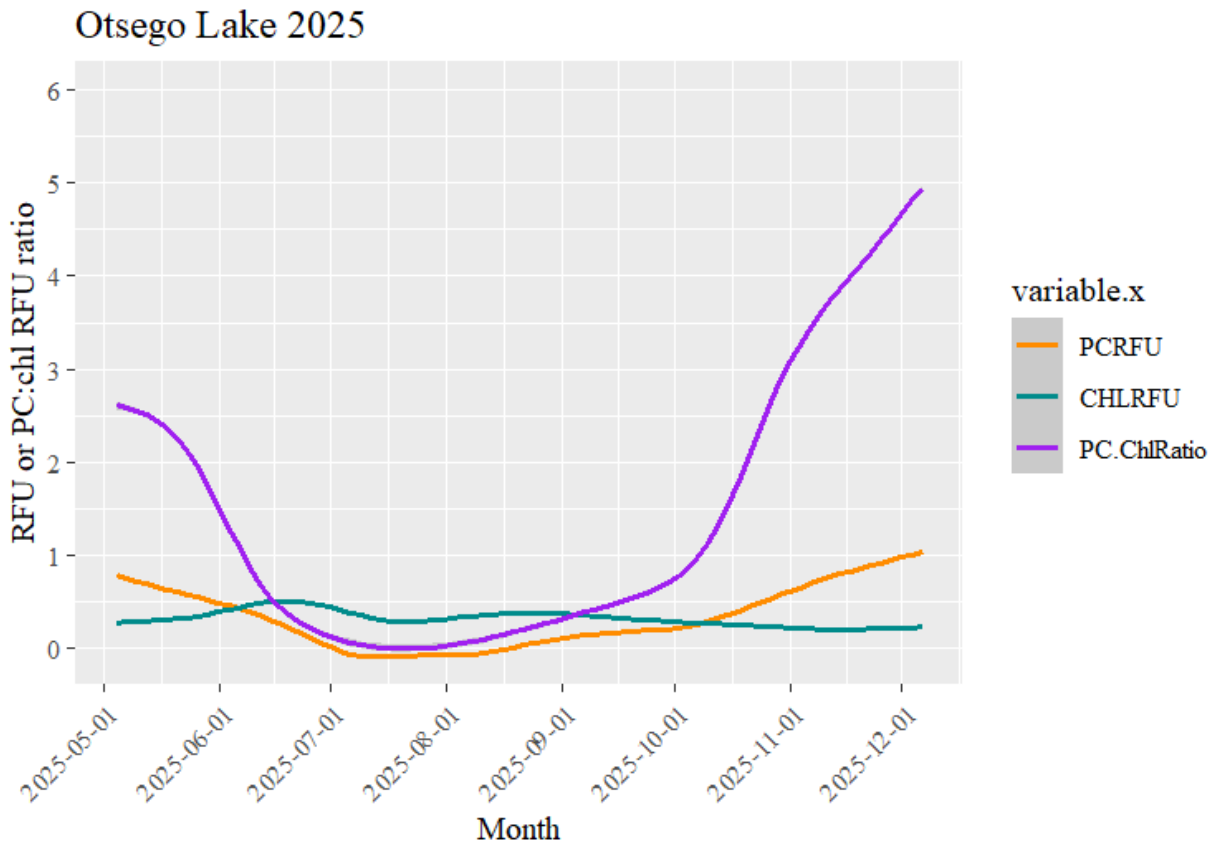
Cool air (11-16 °C = 52-61 °F),
gusty (5-10 m/s = 11-22 mph)
wind shifted N -> S-> N in 1.5 hrs

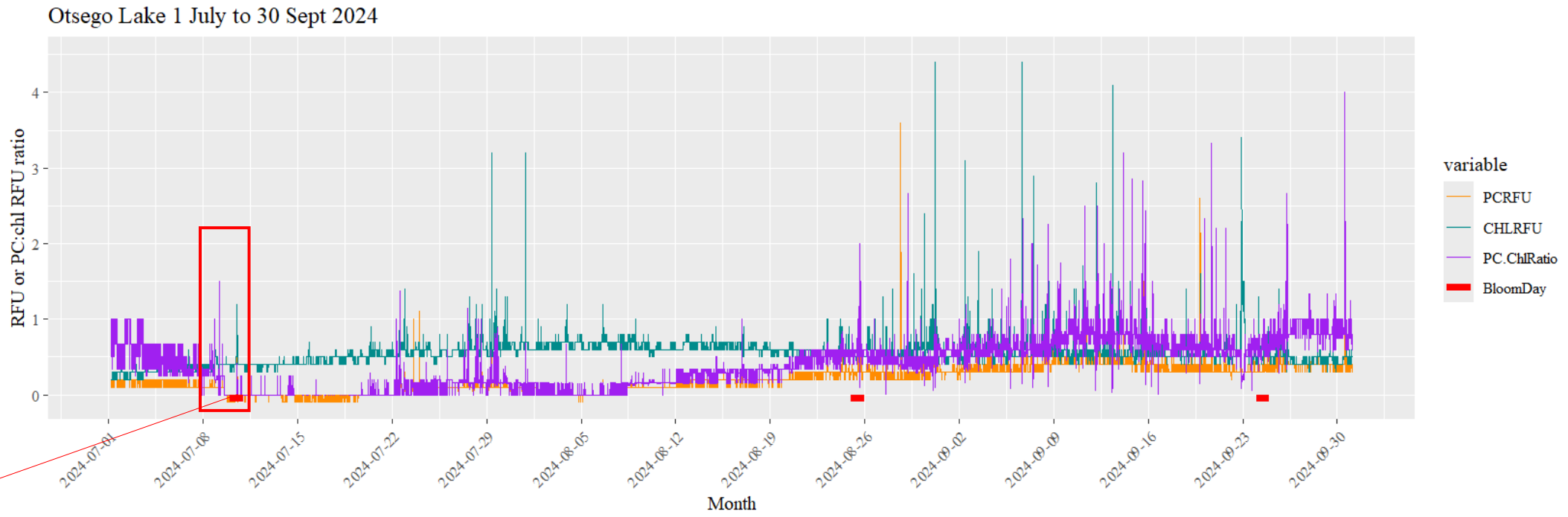

Otsego Lake 1-30 Sept 2025
RFU or PC:chl RFU ratio
0
1
2
3
4
5
2025-09-01
2025-09-08
2025-09-15
2025-09-22
2025-09-29
Month
PCRFU
CHLRFU
PC.ChlRatio
BloomDay


Otsego Lake 1-31 Oct 2025
RFU or PC:chl RFU ratio
0
2
4
6
2025-10-06
2025-10-13
2025-10-20
2025-10-27
Month
variable
PCRFU
CHLRFU
PC.ChlRatio
BloomDay

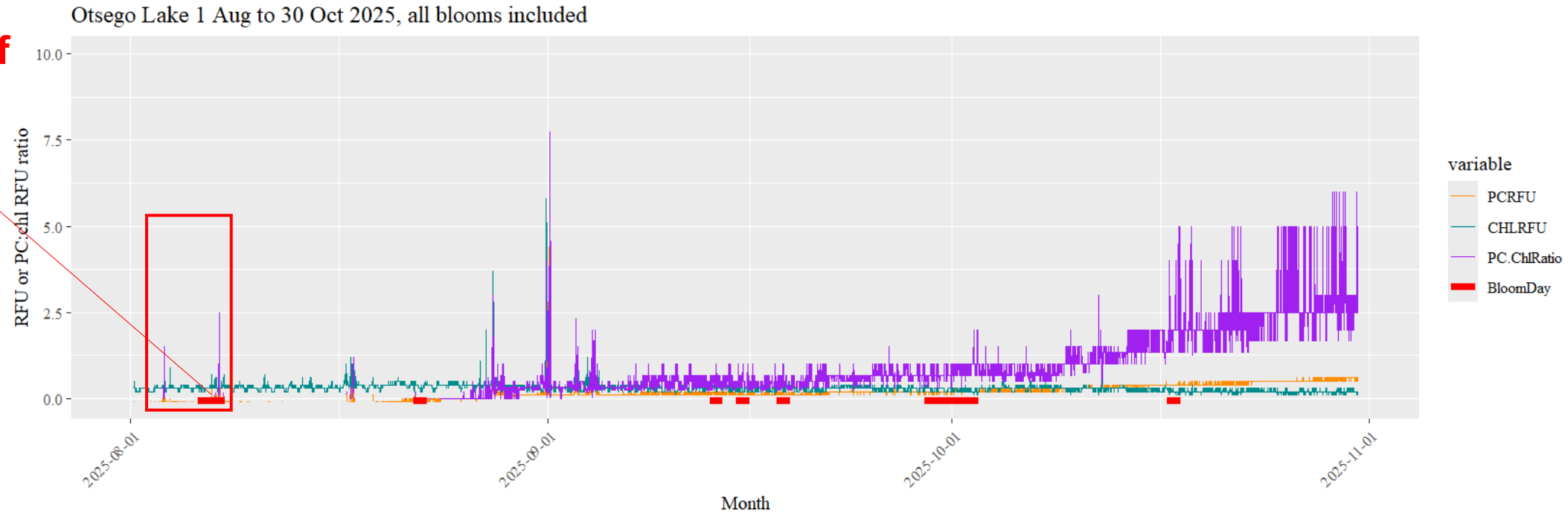
2024 vs 2025 – similar U-shape for PC:Chl







1st reported blooms of the year



Technology Enablers

- Traditional data download into spreadsheets
- Cloud storage of high frequency data
- Display on webpage for greater accessibility, e.g. :
  - https://otsegolakeassociation.org/bfs/last24RFU.php
  - https://lipnickey.com/norm-rfu/
- Proactive monitoring using server Cron functionality.
  - Every 15 minutes, ratio is tested. When (PC > Chl) email alert is sent
    - With webpage reference

Conclusions

- Use of PC: Chl RFU ratio with other indicators (e.g. Secchi, surface visual condition) can provide timely prediction to lake managers of impending blooms
- Higher frequency data are more informative (especially for manual collection)
- Patterns are highly lake-specific – need to collect data for your lake for multiple years to discern its pattern
- Potential for predicting biomass/cell count from RFUs – ***if*** blooms are dominated by a single species, with lab-based calibration

Acknowledgement

- Normanoch Association (Culver Lake NJ)
- Otsego Lake Association
- SUNY Oneonta BFS Volunteer Dive Team
- School of Sciences & Biological Field Station, SUNY Oneonta
- National Science Foundation
- NYS Water Resources Institute
- Great Lake Research Consortium
- Otsego County Conservation Association
- Cooperstown Rotary Club
- Logistical support/approval from: Otsego County Conservation Association; Glimmerglass Condominium Homeowners' Association; Otsego County Sheriff's Office; NYS Parks, Recreation & Historic Preservation; Flynn, Richtsmeier, VanHeusen, and Willies Families, collaborators from the Global Lake Ecological Observatory Network (GLEON), and Northeast GLEON (NE GLEON), and others

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